*Phytochemistry*, Vol. 20, No. 8, pp. 1915–1918, 1981.
Printed in Great Britain.

0031–9422/81/081915–04 $02.00/0


# POILANEIC ACID, A CEMBRANOID DITERPENE FROM *CROTON POILANEI*

AIYA SATO, MASAAKI KURABAYASHI, AKIRA OGISO and HARUMITSU KUWANO

Central Research Laboratories, Sankyo Co. Ltd., 1-2-58 Hiromachi Shinagawa-ku, Tokyo 140, Japan

(*Received* 14 *November* 1980)

**Key Word Index**—*Croton poilanei*; Euphorbiaceae; cembranoid diterpene; poilaneic acid.

**Abstract**—Poilaneic acid, a cembranoid diterpene from *Croton poilanei*, has been characterized as (1*R**,2*E*,4*Z*,7*E*,11*Z*)-12-carboxyl-1-isopropyl-4,8-dimethylcyclotetradecatetraene.

## INTRODUCTION

In the course of a chemotaxonomic study of the genus *Croton*, which grows wild in Thailand [1, 2], we isolated poilaneic acid (**1a**), a cembranoid diterpene, from *Croton poilanei* Gagnep. [3]. Although cembranoid diterpenes have been isolated from a variety of terrestrial as well as marine sources [4–16], there have been no reports of their isolation from *Croton* sp. We now report the characterization of poilaneic acid (**1a**).

## RESULTS AND DISCUSSION

Silica gel chromatography of *n*-hexane-soluble acidic material from *C. poilanei* gave poilaneic acid (**1a**), mp 94–95°, $[\alpha]_D^{25}$ −136.8° ($CHCl_3$). High resolution MS gave a MW consistent with the formula $C_{20}H_{30}O_2$ (calc: 302.2245. found: 302.2241). Its $^1H$ NMR spectrum indicated that **1a** possessed an isopropyl group ($\delta$ 0.80 and 0.84), two olefinic methyl groups ($\delta$ 1.66 and 1.82), and five olefinic protons ($\delta$ 5.0–6.2). Moreover, its $^{13}C$ NMR spectrum showed the presence of eleven $sp^3$ carbons (4 quartets, 5 triplets and 2 doublets), eight $sp^2$ carbons (5 doublets and 3 singlets) and a carboxyl carbon. Its UV spectrum, $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 223 (4.1), 245 (sh), 255 (sh), showed the presence of a conjugated diene and an $\alpha,\beta$-unsaturated carboxylic acid ($\nu_{max}^{nujol}$ $cm^{-1}$: 1680). Catalytic hydrogenation of the methyl ester of **1a** (**1b**) over Pt gave a mixture of epimeric octahydro derivatives (**2**), which confirmed that **1a** contained four double bonds and had a cembranoid skeleton.

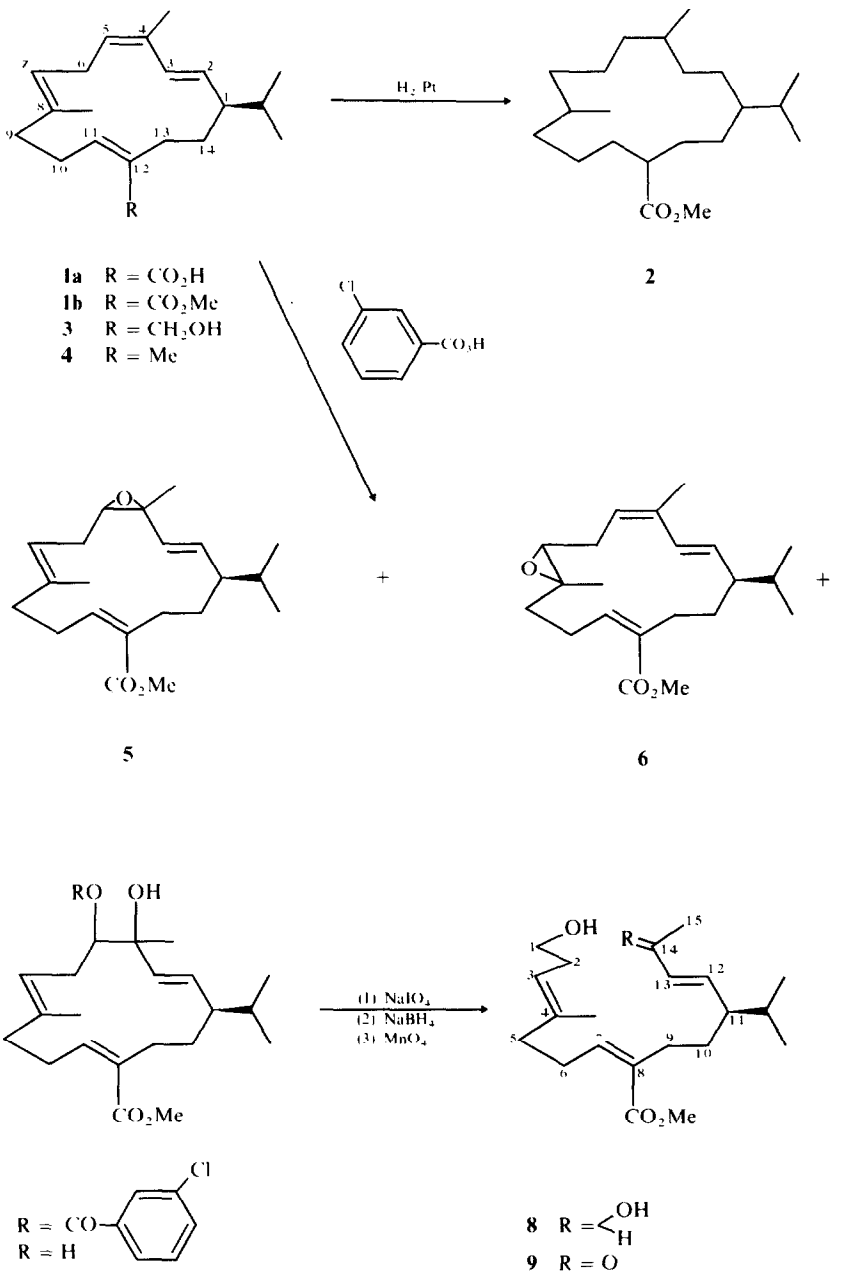
To determine the gross structure, **1b** was reduced with $LiAlH_4$ to give the alcohol **3**, mp 92–94°, $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 238 (sh), 244 (4.4), 253 (sh), and then **3** was converted to (−)-cembrene (**4**), mp 58–58.3°, $[\alpha]_D^{25}$ −232° ($CHCl_3$), on treatment of the corresponding mesylate with $LiAlH_4$. The (−)-cembrene obtained [16] was identical with (+)-cembrene [17–19] in all physiochemical data except for the sign of optical rotation. This established that poilaneic acid (**1a**) had the cembrene skeleton with *R*-chirality at C-1 and that one of three olefinic methyl groups in (−)-cembrene was biogenetically oxidized to a carboxyl group.

On treatment with *m*-chloroperbenzoic acid in $CH_2Cl_2$ at −20°, **1b** initially gave the labile epoxide **5**, as a major product, together with a small amount of **6**. The epoxide **5** was readily cleaved to the glycol mono *m*-chlorobenzoate (**7a**) on standing at ambient temperature, and during separation on silica gel, the ester **7a** was easily hydrolysed to the glycol **7b** as the final product. The UV spectrum of **7b**, $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 223 (4.1), showed the absence of the conjugated diene chromophore and the high-field shift of the methyl signal ($\delta$ 1.36) in the $^1H$ NMR spectrum indicated that the methyl group was situated on the conjugated diene and that the carboxyl group was on the other double bond.

Oxidative cleavage of **7b** with $NaIO_4$ in aqueous dioxane followed by $NaBH_4$ reduction gave the diol **8**, which was refluxed over $MnO_2$ in $CHCl_3$ to yield the $\alpha,\beta$-unsaturated ketone **9**, UV $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 222 (4.1), IR $\nu_{max}^{liquid}$ $cm^{-1}$: 3430, 1715, 1675. In the $^1H$ NMR spectrum of **9**, irradiation of the triplet at $\delta$ 5.14 (H-3) sharpened the broad singlet at $\delta$ 1.64 (Me-4) and collapsed the signal at $\delta$ 2.29 (H-2) to a triplet. Moreover, on irradiation of the signal (H-2), the triplet at $\delta$ 3.59 (H-1) collapsed to a singlet. These results agreed with the structure **9**, indicating that the carboxyl group was situated at C-12 in **1a**. Consequently, poilaneic acid was identified as (1*R**,2*E*,4*Z*,7*E*,11*Z*)-12-carboxyl-1-iso-propyl-4,8-dimethylcyclotetradecatatetraene.

## EXPERIMENTAL

*Extraction and isolation.* Powdered leaves (3.3 kg) of *C. poilanei* were extracted with MeOH under reflux. After evapn of the solvent, the residue was dissolved in 80% aq. MeOH and extracted with *n*-hexane. The *n*-hexane extract was concd to a yellow-green oil (144 g). A soln of the extract (100 g) in *n*-hexane (400 ml) was swirled with 5% NaOH (400 ml) at ambient temp. The aq. layer was acidified with conc. HCl with cooling at 0°, and extracted with *n*-hexane. After usual work-up, the residue (70 g) was subjected to Si gel column chromatography. Elution with $C_6H_6$ gave colourless crystals, which were recrystallized from aq. MeOH to yield poilaneic acid (37 g), mp 94–95°, $[\alpha]_D^{25}$ −136.8° ($CHCl_3$; *c* 0.33). IR $\nu_{max}^{nujol}$ $cm^{-1}$: 3000, 1680, 1620; UV $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 223 (4.1), 245 (sh), 255 (sh); $^1H$ NMR (100 MHz, $CDCl_3$): $\delta$ 0.80 (3 H, *d*, *J* = 6.5 Hz), 0.83 (3 H, *d*, *J* = 6.5 Hz), 1.66 (3 H, *t*, *J* = 1.5 Hz), 1.82 (3 H, *t*, *J* = 1.5 Hz), 1.5–2.5 (11 H, *m*), 3.05 (1 H, *ddd*, *J* = 6.0, 9.5, 15.5 Hz), 5.21 (1 H, *dd*, *J* = 9.5, 15.5 Hz), 5.56 (1 H, *dd*, *J* = 6.0, 9.5 Hz), 6.04 (1 H, *dd*, *J* = 4.5, 6.5 Hz), 6.05 (1 H, *d*, *J* = 15.5 Hz); $^{13}C$ NMR (25.2 MHz, $CDCl_3$): $\delta$ 14.51 (*q*), 19.38 (*q*), 19.98 (*q*), 20.98 (*q*), 25.92 (*t*), 26.27 (*t*), 29.52 (*t*), 32.15 (*d*), 32.78 (*t*), 38.58 (*t*), 47.96 (*d*), 125.73 (*d*), 128.04 (*d*), 128.88 (*s*), 130.54 (*d*), 131.00 (*s*), 131.30 (*d*), 135.17 (*s*), 147.81 (*d*), 173.69 (*s*). MS (probe)




75 eV *m/z* (rel. int.): 302 (27), 259 (17), 213 (17), 133 (50), 121 (53), 119 (53), 107 (70), 105 (70), 93 (100), 91 (80), 81 (60), 79 (60). (Found: C, 79.43; H, 10.00. $C_{20}H_{30}O_2$ requires: C, 79.47; H, 9.93%).

*Esterification of* **1a**. A soln of **1a** (4.5 g) and MeI (2 ml) in dry DMF (20 ml) was stirred in the presence of $K_2CO_3$ (1.8 g) at ambient temp. overnight. After usual work-up, the residue was distilled to give **1b** (4.4 g), bp 160–170° (bath temp.)/0.2 mm Hg. IR $\nu_{max}^{liquid}$ $cm^{-1}$: 1715, 1615, 1610, 1430, 1380, 1245, 1200; $^1H$ NMR (100 MHz, $CDCl_3$): $\delta$ 0.80 (3 H, *d*, *J* = 6.5 Hz), 0.83 (3 H, *d*, *J* = 6.5 Hz), 1.66 3 H, *s* (*br*), 1.80 (3 H, *s* (*br*), 1.5–2.6 (11 H, *m*), 3.02 (1 H, *m*), 3.72 (3 *H*, *s*), 5.10 (1 H, *dd*, *J* = 9.0, 15.5 Hz), 5.16 (1 H, *dd*, *J* = 3.5, 11.0 Hz), 5.52 (1 H, *m*), 5.81 (1 H, *m*), 6.07 (1 H, *d*, *J* = 15.5 Hz); MS (probe), 75 eV, *m/z* (rel. int.): 316 (22), 273 (10), 213 (26), 133 (50), 121 (61), 119 (61), 107 (74), 105 (74), 93 (100), 91 (82), 81 (61), 79 (61). (Found: C, 79.75; H, 10.13. $C_{21}H_{32}O_2$ requires: C, 79.61; H, 10.20%).

*Catalytic hydrogenation of* **1b**. A soln of **1b** (0.150 g) in MeOH (15 ml) was shaken over Pt (0.015 g) under $H_2$. After filtration, the residue was distilled to give **2** (0.140 g), bp 130° (bath temp.)/0.15 mm Hg. IR $\nu_{max}^{liquid}$ $cm^{-1}$: 1740, 1465, 1435, 1380, 1265, 1190, 1160; MS (probe), 75 eV, *m/z* (rel. int.): 324 (100), 291 (25). (Found: C, 77.89; H, 12.29. $C_{21}H_{40}O_2$ requires: C, 77.78; H, 12.35%).

*Conversion of* **1b** *to* (−)-*cembrene*. (a) A soln of **1b** (1.3 g) in dry $Et_2O$ (10 ml) was added to a soln of $LiAlH_4$ (0.9 g) in dry $Et_2O$ (20 ml) at 0°, and then stirred at ambient temp. for 2 hr. After usual work-up, the residue was subjected to Si gel

chromatography. Elution with $C_6H_6$–EtOAc (20:1) gave colourless crystals, which were recrystallized from *n*-hexane to yield **3** (0.84 g), mp 92–94°. IR $\nu_{max}^{nujol}$ $cm^{-1}$: 3250, 1650, 1600; $^1H$ NMR (100 MHz, $CDCl_3$): $\delta$ 0.80 (3 H, *d*, $J$ = 6.5 Hz), 0.85 (3 H, *d*, $J$ = 6.5 Hz), 1.58 (3 H, *t*, $J$ = 1.4 Hz), 1.78 (3 H, *t*, $J$ = 1.5 Hz), 1.6–2.7 (11 H, *m*), 3.00 (1 H, *m*), 4.00 (1 H, *d*, $J$ = 12.0 Hz), 4.23 (1 H, *d*, $J$ = 12.0 Hz), 5.0–5.8 (4 H, *m*), 6.06 (1 H, *d*, $J$ = 15.5 Hz); $^{13}C$ NMR (25.2 MHz, $CDCl_3$): $\delta$ 14.39 (*q*), 19.76 (*q*), 19.88 (*q*), 20.83 (*q*), 22.78 (*t*), 26.20 (*t*), 27.96 (*t*), 32.40 (*t*), 32.79 (*d*), 38.68 (*t*), 48.50 (*d*), 59.15 (*t*), 125.35 (*d*), 127.00 (*d*), 129.36 (*d*), 130.24 (*d*), 130.55 (*s*), 130.68 (*d*), 134.89 (*s*), 135.86 (*s*); UV $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 238 (sh), 244 (4.4), 253 (sh); MS (probe), 75 eV, *m/z* (rel. int.): 288 (21), 270 (14), 245 (14), 227 (26), 133 (57), 131 (36), 121 (55), 119 (69), 93 (100), 91 (90), 81 (81), 79 (79). (Found: C, 83.33; H, 11.11. $C_{20}H_{32}O$ requires: C, 83.45; H, 11.07%).

(b) A mixture of **3** (0.396 g), $MeSO_2Cl$ (0.4 ml), and pyridine (0.2 ml) in dry $CH_2Cl_2$ (0.4 ml) was stirred at ambient temp. overnight. After usual work-up, the residue (0.5 g) in dry $Et_2O$ (10 ml) was added to a soln of $LiAlH_4$ (0.050 g) in dry $Et_2O$ (10 ml) with cooling at 0° and stirred at ambient temp. for 5 hr. After usual work-up, the *n*-hexane extract (0.2 g) was purified by prep. TLC (*n*-hexane) to yield (−)-cembrene (0.100 g), which was recrystallized from EtOH, mp 58–58.3°, $[\alpha]_D^{25}$ −232° ($CHCl_3$; *c* 0.41). IR $\nu_{max}^{CS_2}$ $cm^{-1}$: 2930, 1660, 1640, 1385, 1160, 965, 942, 915, 840, 790; $^1H$ NMR (100 MHz, $CCl_4$): $\delta$ 0.80 (3 H, *d*, $J$ = 6.5 Hz), 0.85 (3 H, *d*, $J$ = 6.5 Hz), 1.48 (3 H, *s* (*br*)), 1.57 (3 H, *s* (*br*)), 1.75 (3 H, *s* (*br*)), 1.6–2.5 (11 H, *m*), 3.00 (1 H, *m*), 4.7–5.7 (4 H, *m*), 6.04 (1 H, *d*, $J$ = 15.3 Hz); $^{13}C$ NMR (25.2 MHz, $CDCl_3$): $\delta$ 14.34 (2*q*), 19.96 (2*q*), 20.88 (*q*), 23.60 (*t*), 26.35 (*t*), 27.92 (*t*), 32.96 (*d*), 36.67 (*t*), 39.04 (*t*), 48.39 (*d*), 125.75 (*d*), 126.12 (*d*), 126.92 (*d*), 130.83 (*d*), 131.24 (*d*), 131.50 (*s*), 132.81 (*s*), 135.50 (*s*); UV $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 245 (4.1); MS (probe), 75 eV, *m/z* (rel. int.): 272 (27), 229 (43), 161 (30), 147 (27), 133 (37), 121 (54), 119 (67), 107 (72), 105 (72), 95 (36), 93 (100), 91 (61), 81 (85), 79 (47), 77 (32), 69 (40), 67 (34), 55 (54), 41 (67). (Found: C, 88.52; H, 11.89. $C_{20}H_{32}$ requires: C, 88.24; H, 11.76%).

*Epoxidation of* **1b**. To a soln of **1b** (3.0 g) in dry $CH_2Cl_2$ (30 ml) was added 85% *m*-chloroperbenzoic acid (2.8 g) in small portions at −20°. After the addition was complete, the reaction mixture was stirred at ambient temp. for 2 hr and then treated with satd $NaHCO_3$. The $CH_2Cl_2$ layer, after usual work-up, was subjected to Si gel chromatography. Fraction 1, eluted with $C_6H_6$, contained **5** (0.270 g), colourless oil. Fraction 2, eluted with $C_6H_6$–EtOAc (20:1) contained **6** (0.142 g), which was recrystallized from cold *n*-hexane. Fraction 3, eluted with $C_6H_6$–EtOAc (5:1), contained **7a** (0.150 g), colourless oil. Fraction 4, eluted with $C_6H_6$–EtOAc (1:1), contained **7b** (0.850 g), colourless oil. **5**: $^1H$ NMR (60 MHz, $CDCl_3$): $\delta$ 1.11, 1.22 (3 H, *s*), 1.67 (3 H, *s*), 3.70 (3 H, *s*); UV $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 220 (4.2). (Found: C, 75.67; H, 12.85. $C_{21}H_{32}O_3$ requires: C, 75.90; H, 12.70%). **6**: mp 83.5–84°; IR $\nu_{max}^{nujol}$ $cm^{-1}$: 1715, 1645, 1460, 1200; UV $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 225 (sh), 237 (4.4), 240 (sh), 250 (sh); $^1H$ NMR (100 MHz, $CDCl_3$): $\delta$ 0.80 (3 H, *d*, $J$ = 6.5 Hz), 0.83 (3 H, *d*, $J$ = 6.5 Hz), 1.37 (3 H, *s*), 1.84 (3 H, *s* (*br*)), 1.3–2.6 (12 H, *m*), 2.70 (1 H, *m*), 2.73 (1 H, *d* (*br*), $J$ = 7.0 Hz), 3.74 (3 H, *s*), 5.31 (1 H, *dd*, $J$ = 10.0, 15.5 Hz), 5.5–5.8 (2 H, *m*), 6.10 (1 H, *d*, $J$ = 15.5 Hz); MS (probe), 75 eV, *m/z* (rel. int.): 332 (55), 257 (27), 149 (83), 135 (37), 120 (49), 107 (95), 105 (53), 93 (100), 91 (65), 81 (63), 79 (80). (Found: C, 75.94; H, 12.71. $C_{21}H_{32}O_3$ requires: C, 75.90; H, 12.70%). **7a**: IR $\nu_{max}^{liquid}$ $cm^{-1}$: 3500, 1715, 1640, 1440, 1385, 1250, 1210; $^1H$ NMR (60 MHz, $CDCl_3$): $\delta$ 0.80 (3 H, *d*, $J$ = 6.5 Hz), 0.83 (3 H, *d*, $J$ = 6.5 Hz), 1.67 (3 H, *s*), 1.75 (3 H, *s*), 1.2–2.8 (12 H, *m*), 3.75 (3 H, *s*), 4.56 (1 H, *s* (*br*)), 5.4–6.2 (4 H, *m*), 7.4–7.6 (2 H, *m*), 7.9–8.2 (2 H, *m*). (Found: C, 68.51; H, 7.70; Cl, 7.14. $C_{28}H_{37}ClO_5$ requires: C, 68.77; H, 7.57; Cl, 7.29%). **7b**: IR $\nu_{max}^{liquid}$ $cm^{-1}$: 3430, 1720, 1640, 1440, 1390, 1210; $^1H$ NMR (100 MHz, $CDCl_3$): $\delta$ 0.80 (3 H, *d*, $J$ = 6.5 Hz), 0.83 (3 H, *d*, $J$ = 6.5 Hz), 1.36 (3 H, *s*), 1.65 (3 H, *s*), 1.6–2.6 (12 H, *m*), 3.50 (1 H, *dd*, $J$ = 2.0, 7.5 Hz), 3.73 (3 H, *s*), 5.29 (1 H, *t* (*br*), $J$ = 7.5 Hz), 5.44 (1 H, *dd*, $J$ = 8.0, 15.5 Hz), 5.66 (1 H, *d*, $J$ = 15.5 Hz), 5.76 (1 H, *dd*, $J$ = 6.0, 7.0 Hz); MS (probe), 75 eV, *m/z* (rel. int.): 350 (8), 332 (12), 276 (48), 257 (44), 177 (98), 169 (100), 95 (84), 93 (76), (Found: C, 71.82; H, 9.60. $C_{21}H_{34}O_4$ requires: C, 72.00; H, 9.71%).

*Oxidative cleavage of* **7b**. To a soln of **7b** (0.300 g) in dioxane (4 ml) was added an aq. soln of $NaIO_4$ (0.400 g) and the mixture was stirred at ambient temp. for 1 hr. The reaction mixture was poured into $H_2O$ and extracted with $Et_2O$. After usual work-up, the $Et_2O$ extract was added to a soln of $NaBH_4$ (0.050 g) in EtOH (5 ml). After stirring at ambient temp. for 30 min and usual work-up, the $Et_2O$ extract was subjected to Si gel chromatography. Elution with $C_6H_6$–EtOAc (1:1) gave **8** (0.161 g), colourless oil. IR $\nu_{max}^{liquid}$ $cm^{-1}$: 3520, 1715, 1630, 1440, 1380, 1200, 1155; $^1H$ NMR (100 MHz, $CDCl_3$): $\delta$ 0.81 (3 H, *d*, $J$ = 6.5 Hz), 0.86 (3 H, *d*, $J$ = 6.5 Hz), 1.27 (3 H, *d*, $J$ = 7.0 Hz), 1.64 (3 H, *s* (*br*)), 1.3–2.7 (12 H, *m*), 3.60 (2 H, *t*, $J$ = 7.0 Hz), 3.72 (3 H, *s*), 4.27 (1 H, *m*), 5.1–5.8 (4 H, *m*); MS (probe), 75 eV, *m/z* (rel. int.): 352 (2), 334 (2), 300 (33), 289 (26), 257 (50), 229 (67), 161 (48), 121 (56), 107 (67), 95 (74), 81 (100). (Found: C, 71.51; H, 10.29. $C_{21}H_{36}O_4$ requires: C, 71.59; H, 10.23%).

*Oxidation of* **8** *with* $MnO_2$. A mixture of **8** (0.290 g) and $MnO_2$ (3.0 g) was refluxed in $CHCl_3$ (15 ml) for 4 hr. After usual work-up, the residue was subjected to Si gel chromatography. Elution with $C_6H_6$–EtOAc (5:1) gave **9** (0.149 g), colourless oil. IR $\nu_{max}^{liquid}$ $cm^{-1}$: 3430, 1715, 1675, 1610; UV $\lambda_{max}^{EtOH}$ nm (log $\varepsilon$): 222 (4.1); $^1H$ NMR (100 MHz, $CDCl_3$): $\delta$ 0.85 (3 H, *d*, $J$ = 6.5 Hz), 0.89 (3 H, *d*, $J$ = 6.5 Hz), 1.64 (3 H, *s* (*br*)), 2.26 (3 H, *s*), 1.3–2.2 (8 H, *m*), 2.29 (2 H, *td*, $J$ = 6.0, 7.0 Hz), 2.53 (2 H, *td*, $J$ = 7.0, 7.5 Hz), 3.61 (2 H, *t*, $J$ = 6.0 Hz), 3.73 (3 H, *s*), 5.14 (1 H, *t*, $J$ = 7.0 Hz), 5.81 (1 H, *t*, $J$ = 7.5 Hz), 6.02 (1 H, *d*, $J$ = 16.0 Hz), 6.57 (1 H, *dd*, $J$ = 9.2, 16.0 Hz); MS (probe), 75 eV, *m/z* (rel. int.): 350 (13), 318 (33), 299 (49), 287 (40), 225 (28), 168 (80), 106 (80), 84 (100), 80 (93). (Found: C, 72.14; H, 9.75. $C_{21}H_{34}O_4$ requires: C, 72.00; H, 9.71%).

*Acknowledgements*—We are indebted to Mr. Ananta Laophanich of Asian TJD Enterprize Ltd., Thailand and Mr. Chana Promdej of Royal Forest Department in Thailand for collection of the plant.

## REFERENCES

1. Sato, A., Ogiso, A. and Kuwano, H. (1980) *Phytochemistry* **19**, 2207.
2. Kitazawa, H. and Ogiso, A. (1981) *Phytochemistry* **20**, 287.
3. Shaw, A. (1972) *Kew Bull.* **26**, 191.
4. Weinheimer, J. A., Chang, C. W. J. and Matson, J. A. (1978) *Fortschr. Chem. Org. Naturst.* **36**, 285.
5. Favi, B. N. and Faulkner, D. J. (1978) *J. Org. Chem.* **43**, 2117.
6. Bowden, B. F., Coll, J. C., Hicks, W., Kazlauskas, R. and Mitchell, S. J. (1978) *Aust. J. Chem.* **31**, 2702.
7. Pardhy, R. S. and Bhattacharyya, S. C. (1978) *Indian J. Chem. Sect. B* **16**, 171.
8. Klein, E. and Obermann, H. (1978) *Tetrahedron Letters* 349.
9. Groweiss, A., Kashman, Y., Vanderah, D. J., Tursch, B., Cornet, P., Braekman, J. C. and Dolozse, D. (1978) *Bull. Soc. Chim. Belg.* **87**, 277.
10. Kashman, Y., Bodner, M., Loya, Y. and Benayahu, Y. (1978) *Isr. J. Chem.* **16**, 1.
11. Bowden, B. F., Coll, J. C., Michell, S. J. and Stokie, G. J. (1979) *Aust. J. Chem.* **32**, 635.

12. Weiner, D. J., Meinwald, J., Prestwich, G. D., and Miura, I. (1979) *J. Org. Chem.* **44**, 3950.
13. Kobayashi, M., Nakagawa, T., and Mitsuhashi, H. (1979) *Chem. Pharm. Bull.* **27**, 2382.
14. Yamada, Y. (1979) *Chem. Pharm. Bull.* **27**, 2394.
15. Frincke, J. M., Milntyre, D. E. and Faulkner, D. J. (1980) *Tetrahedron Letters* 735.
16. Uchio, Y., Nakayama, M., Hayashi, S. and Hase, T. (1980) *41th Natl. Meet. Chem. Soc. Jpn (Osaka)* p. 1096.
17. Dauben, W. J., Thiesen, W. E. and Resnick, P. R. (1965) *J. Org. Chem.* **30**, 1693.
18. Prasada, R. and Sukh, D. (1976) *Tetrahedron* **32**, 1437.
19. Kimland, J. and Norin, T. (1968) *Acta Chem. Scand.* **22**, 943.